

## CHAPTER II - RECONNAISSANCE & COMMUNICATIONS

### 1. GENERAL

The Joint Typhoon Warning Center depends on reconnaissance to provide necessary, accurate and timely meteorological information in support of each warning. The JTWC relies primarily on three sources of reconnaissance: aircraft, satellite and radar. Optimum utilization of all available reconnaissance assets is obtained through use of the Selective Reconnaissance Program (SRP) whereby various factors are considered in selecting a specific reconnaissance platform for each warning. Factors include: the cyclone's location and intensity, reconnaissance platform availability, current operations, limitation of reconnaissance assets, and the cyclone's threat to life/property. A listing of reconnaissance fixes used this season can be found in Chapter VI. Timely receipt of reconnaissance data is extremely important to the typhoon warning service. Similarly, a warning is useless unless it can be received by customers in a timely fashion. Therefore, efficient communications into and out of JTWC is invaluable.

### 2. RECONNAISSANCE

#### a. AIRCRAFT:

Aircraft weather reconnaissance is performed in the JTWC area of responsibility by the 54th Weather Reconnaissance Squadron (54 WRS). The squadron, presently equipped with six WC-130 aircraft, is located at Andersen Air Force Base, Guam. From July through October, augmentation by the 53rd Weather Reconnaissance Squadron at Keesler Air Force Base, Mississippi brings the total number of available aircraft to nine. The JTWC reconnaissance requirements are provided daily throughout the year to the Tropical Cyclone Aircraft Reconnaissance Coordinator (TCARC). These requirements include area(s) to be investigated, tropical cyclone(s) to be fixed, fix times, and forecast position of fix. In accordance with CINCPACINST 3140.1M, "Usage of reconnaissance assets in acquiring meteorological data from aircraft, satellites and land-based radar shall be at the discretion of FLEWEACEN/JTWC Guam based on the following priorities:

(1) Alert flights and vortex or center fixes as required for issuance of tropical cyclone warnings in the Pacific area of responsibility;

(2) Center or vortex fixes as required for issuance of tropical cyclone warnings in the Indian Ocean area of responsibility;

(3) Supplementary fixes; and

(4) Synoptic data acquisition".

As in previous years, aircraft reconnaissance provided direct measurements of height, temperature, flight level winds, sea level pressure, estimated surface winds (when observable) and numerous additional parameters.

The meteorological data is gathered by the Aerial Weather Reconnaissance Officers and dropsonde operators of Detachment 4, Hq AWS who crew with the 54th. These data provide the Typhoon Duty Officer indications of changing cyclone characteristics, radius of cyclone associated winds and position and intensity determinations. Another important aspect of this data is its availability for research in tropical cyclone analysis and forecasting. Aircraft reconnaissance will become even more important in years to come when high-resolution tropical cyclone dynamic steering programs will require a dense input of wind and temperature data.

#### b. SATELLITE

Satellite fixes from USAF ground sites and USN ships provide day and night coverage in the JTWC area of responsibility. Interpretation of this satellite imagery provides cyclone positions, and for daytime passes estimates of storm intensities are also made through the Dvorak technique.

Detachment 1, 1st Weather Wing on Guam is the primary fix site for the western North Pacific. Both DMSP and NOAA data are received and processed. DMSP fix positions received at JTWC from the Air Force Global Weather Central (AFGWC), Offutt Air Force Base, Nebraska were the major source of satellite data for the Indian Ocean. NOAA satellite fixes were also received from Fleet Weather Facility (FLEWEAFAC), Suitland, Maryland for the western Pacific and Indian Ocean areas. GOES fixes were also provided by the National Environmental Satellite Service, Honolulu, Hawaii for the storms near the dateline.

#### c. RADAR

Land radar also provides very useful positioning data on well developed cyclones when in proximity (usually within 175 nm of the radar site) of the Republic of the Philippines, the Republic of China, Hong Kong, Japan (including the Ryukyu Islands), the Republic of Korea, and Guam.

### 3. AIRCRAFT RECONNAISSANCE EVALUATION CRITERIA

The following criteria are used to evaluate reconnaissance support to JTWC.

a. Six-hour fixes - To be counted as made on time, a fix must satisfy the following criteria:

(1) Fix must be made not earlier than 1 hr before, nor later than 1/2 hr after scheduled fix time.

(2) Aircraft in area requested by scheduled fix time, but unable to locate center due to:

(a) Cyclone dissipation; or

(b) Rapid acceleration of the cyclone away from the forecast position.

(3) If penetration not possible due to geographic or other flight restrictions, aircraft radar fixes are acceptable.

b. Levied 6-hr fixes made outside the above limits are evaluated as follows:

(1) Early-fix is made within the interval from 3 hr to 1 hr prior to scheduled fix times. However, no credit will be given for early fixes made within 3 hr of the previous fix.

(2) Late-fix is made within the interval from 1/2 hr to 3 hr after scheduled fix time.

c. When 3 hr fixes are levied, they must satisfy the same time criteria discussed above in order to be classified as made on time. Three-hour fixes made that do not meet the above criteria are classified as follows:

(1) Early-fix is made within the interval from 1 1/2 hr to 1 hr prior to schedule fix time.

(2) Late-fix is made within the interval from 1/2 hr to 1 1/2 hr after scheduled fix time.

d. Fixes not meeting the above criteria are scored as missed.

e. Fixes levied as "resources permitting" are not evaluated.

f. Investigatives - to be counted as made on time, investigatives must satisfy the following criteria:

(1) The aircraft must be within 250 nm of the specified point by the scheduled time.

(2) The specified flight level and track must be flown.

(3) Reconnaissance observations are required every half-hour in accordance with AWSM 105-1. Turn and mid-point winds shall be reported on each full observation within 250 nm of the levied point.

(4) Observations are required in all quadrants unless a concentrated investigation in one or more quadrants has been specified.

(5) Aircraft must contact JTWC before leaving area of concern.

g. Investigatives not meeting the time criteria of paragraph f, will be classified as follows:

(1) Late-aircraft is within 250 nm of the specified point after the scheduled time, but prior to the scheduled time plus 2 hr.

(2) Missed-aircraft fails to be within 250 nm of the specified point by the scheduled time plus 2 hr.

#### 4. AIRCRAFT RECONNAISSANCE SUMMARY

During the 1977 tropical cyclone season, 199 six-hourly vortex fixes and 4 supplementary vortex fixes were levied (Table 2-1). This was 114 less than during 1976. There were fewer tropical cyclones (4) and 169 fewer warnings issued. Increased reliance on satellite data as a fix platform and utilization of aircraft for synoptic data accounted for the lower percentage of aircraft fixes. For example in 1976, 310 aircraft fixes were levied for 661 warnings (46.9%) while in 1977 only 203 fixes were levied for 494 warnings (41.1%). In addition to vortex fixes, 42 investigative missions were levied during 1977 compared with 34 in 1976. Various factors accounted for the increase. In 1977 only 3 storms had no investigatives because of distances involved while 11 storms had 2 or more and 7 investigatives were levied on systems that did not develop. In 1976 7 storms had no investigatives with only 2 storms having 2 investigatives each.

Reconnaissance effectiveness is summarized in Table 2-1. The missed fix rate of 1.5% is the best in recent years.

TABLE 2-1. AIRCRAFT RECONNAISSANCE EFFECTIVENESS

EFFECTIVENESS	NUMBER OF FIXES	PERCENT
COMPLETED ON TIME	189	93.1
EARLY	0	0.0
LATE	11	5.4
MISSED	3	1.5
TOTAL	203	100.0

#### LEVIED VS. MISSED FIXES

	LEVIED	MISSED	PERCENT
AVERAGE 1965-1970	507	10	2.0
1971	802	61	7.6
1972	624	126	20.2
1973	227	13	5.7
1974	358	30	8.4
1975	217	7	3.2
1976	317	11	3.5
1977	203	3	1.5

#### 5. SATELLITE RECONNAISSANCE SUMMARY

The Air Force provides satellite reconnaissance support to JTWC using meteorological data from polar orbiting meteorological satellites of the Defense Meteorological Satellite Program (DMSP).

A network of tactical DMSP sites at Nimitz Hill, Guam; Clark AB, Philippines; Kadena AB, Japan; Osan AB, Korea; and Hickam AFB, Hawaii provides direct readout coverage north of the equator from the dateline west

into the South China Sea. In February 1977, the Guam site was modified to acquire very high resolution data from the National Oceanic and Atmospheric Administration (NOAA) satellites. The Hawaii site was modified soon after.

The Air Force Global Weather Central (AFGWC) at Offutt AFB, Nebraska using stored data readout provides satellite reconnaissance over the Indian Ocean and backup for the tactical sites in WESTPAC. Det 1, 1WW at Guam, colocated with JTWC, operates the network, tasking appropriate sites for tropical cyclone position reports.

Prior to October 1977, both the technicians who maintain and operate the DMSP ground station equipment and the analysts who interpret the data were members of Air Weather Service (AWS). In October 1977, the technicians became members of the Air Force Communications Service (AFCS) as part of an overall AWS/AFCS maintenance consolidation.

Satellite positions are assigned Position Code Numbers (PCN's) depending on the availability of geography for precise gridding and the state of the tropical cyclone's circulation. These are shown in Table 2-2. Estimates of tropical cyclone intensity are obtained from visual data using the Dvorak technique (NOAA Technical Memorandum NESS 45 and later refinements).

TABLE 2-2. POSITION CODE NUMBERS

PCN	METHOD OF CENTER DETERMINATION/GRIDDING
1	EYE/GEOGRAPHY
2	EYE/EPHEMERIS
3	WELL DEFINED CC/GEOGRAPHY
4	WELL DEFINED CC/EPHEMERIS
5	POORLY DEFINED CC/GEOGRAPHY
6	POORLY DEFINED CC/EPHEMERIS

CC=Circulation Center

Increased satellite availability provided the opportunity to more effectively use satellite reconnaissance through the Selective Reconnaissance Program (SRP). For the first time more than half of JTWC's warnings in WESTPAC (51%) were based on satellite positions of tropical cyclones. In the Indian Ocean, where aircraft and radar were not available, 95.5% of JTWC's warnings were based on satellite fixes.

Use of a dual-site tasking concept which requires at least two DMSP sites to make each JTWC levied tropical cyclone fix has in the past resulted in a 99% reliability in meeting JTWC's satellite fix requirements. However in 1977, this reliability dropped to 94.9% due to an unreliable early afternoon and early morning DMSP satellite.

The loss of data from this satellite was random. Therefore, aircraft reconnaissance was levied to support the 0600Z and 1800Z warnings when appropriate. Radar and NOAA 5 satellite data was also used as primary or backup reconnaissance at these times limiting

the need to revert to extrapolation as a warning base.

A comparison of satellite derived positions and the JTWC Best Track positions is shown in Table 2-3. The relative accuracies of satellite positions can be obtained from this table. However, the values are also a function of the Best Track smoothing process.

Satellite derived fixes were also obtained from: USN ships equipped for DMSP direct readout; the National Environmental Satellite Service using NOAA and GOES data; Fleet Weather Facility (FLEWEAFAC), Suitland, Maryland using stored NOAA data; and, from the Naval Weather Service Environmental Detachment at Diego Garcia using NOAA APT data. This information was invaluable to the warning service. Since these were secondary sources, they were not put through the end of the year evaluation.

TABLE 2-3. Mean Deviations (nm) of DMSP Derived Tropical Cyclone Positions from JTWC Best Track Positions, 1974-1977 (all sites). Number of cases shown in parentheses.

PCN	1974 (ALL SITES)	1975 (ALL SITES)	1976 (ALL SITES)	1977 (ALL SITES)
1	13.6 (224)	11.8 (214)	12.4 (131)	15.7 (134)
2	17.4 ( 37)	20.4 ( 35)	20.1 (124)	19.1 ( 47)
3	20.1 (422)	21.2 (271)	21.7 (161)	22.4 (141)
4	23.9 ( 70)	22.4 ( 50)	29.3 (152)	30.0 ( 75)
5	35.4 (342)	34.2 (323)	40.4 (247)	37.7 (357)
6	49.4 (108)	44.7 ( 71)	49.0 (153)	40.9 (247)
162	14.2 (261)	13.0 (249)	16.1 (255)	16.6 (181)
364	20.6 (492)	21.4 (321)	25.4 (313)	25.0 (216)
566	38.8 (450)	36.1 (394)	43.7 (400)	39.0 (604)

## 6. RADAR RECONNAISSANCE SUMMARY

The 1977 Typhoon season produced a total of 385 radar center fixes accounting for 16.3% of all tropical cyclone fixes in the western Pacific. One radar fix was taken by a WC-130 aircraft of the 54th Weather Reconnaissance Squadron during Tropical Storm Ruth. All other radar fixes were taken by land or ship. The number of storms that were within radar acquisition range this year was 11 compared to 12 last year, but the total number of radar fixes this year was only one half of last year's number. This apparent contradiction is explained by a smaller number of well organized storms especially of the Super Typhoon classification, one versus four last year.

The WMO radar code defines three categories of accuracy for the various national meteorological agencies' radar reports. These categories are: good [within 10 km (5.4 nm)], fair [within 10-30 km (5.4-16.2 nm)] and poor [within 30-50 km (16.2-27 nm)]. This year 287 radar fixes were coded in this manner of which 62% were good, 27% fair and 11% poor. Compared to the JTWC best track, the mean vector deviation for land radar sites was 18.3 nm (34 km) compared to 11.6 nm (21 km) last year and for the one aircraft fix the deviation was 32.4 nm (60 km) compared to 16.0 nm (30 km) last year. This decrease in accuracy is attributable to the smaller number of well organized storms.

Of the total 385 radar fixes this year,

the national meteorological agencies of various countries accounted for 75%; U. S. Air Force, Air Weather Service, Sites 19%; and 5% from aircraft control and warning (AC&W) sites. This year the land radar sites in Taiwan provided a much greater percentage of radar fixes (31%) as compared to previous years due to five storms (Ruth, Thelma, Vera, Amy and Dinah) passing through their area of acquisition. The extensive radar network of the Japan-Ryuku area provided 37% of the total with 13% from Guam and 3% from the Royal Observatory in Hong Kong. The Republic of the Philippines also noticeably increased their coverage, up to 12%, as five storms (Thelma, Sarah, Freda, Kim and Mary) moved through their area. As in previous years, there were no radar fixes taken within the Indian Ocean area.

Of the eleven storms making up this year's number of radar fixes, three typhoons (Babe, Kim and Vera) accounted for 58% of the total. Typhoons Babe and Vera were tracked by the Japanese Meteorological Agency and Taiwan radar sites to account for 40% of the total. All three of these storms were fixed simultaneously by three radar sites on more than one occasion during their tracks.

## 7. COMMUNICATIONS

A new piece of communication equipment, the Naval Environmental Display Station (NEDS) was installed at FWC/JTWC in 1977. The NEDS is an addition to the existing variety of JTWC's communication systems which include the Automatic Voice Switching Network (AUTOVON), the Automatic Digital Network (AUTODIN), the Naval Environmental Data Network (NEDN), and the Air Force Automated Weather Network (AWN). The NEDS has been available, although not yet fully operational, since mid-1977 and promises to add significantly to the efficiency of data receipt and warning preparation. It will eventually replace the current FWC computer which is now providing the graphical display of much of the basic meteorological intelligence received via the NEDN.

The AUTOVON serves as a vital communication link and is a back-up for primary communication systems. AUTODIN is used for dissemination of warnings and other related bulletins which are concurrently transmitted via the AWN. These messages are also relayed for further transmission over US Navy Fleet Broadcasts and to all ships and island stations via US Coast Guard CW (Continuous Wave Morse Code) and voice communications. Inbound message traffic for JTWC is received via AUTODIN addressed to FLEWEACEN GUAM.

Actual message tape preparation and entering of messages into the AUTODIN and AWN circuits is performed by the Nimitz Hill Naval Telecommunications Center (NTCC) of the Naval Communications Area Master Station Western Pacific.

The main data source for JTWC analyses is a dedicated AWN circuit linking JTWC directly to the Automated Digital Weather Switch (ADWS) at Clark AB, RP. The ADWS selects and routes the large volume of meteorological reports necessary to satisfy JTWC requirements for the right data at the right time. At times of primary circuit outage, JTWC has other, though limited and less efficient, teletype data sources. One of these provides data to and from the U. S. Trust Territory, Guam, and the Northern Marianas.

High frequency single sideband (HF/SSB) and phone patch through the USAF aeronautical station at Andersen AFB (Andersen Airways) is the normal means of communication between weather reconnaissance aircraft and JTWC. Depending on storm location or propagation difficulties, the same direct voice contact can be established via AUTOVON through other USAF aeronautical stations, such as Clark, Yokota or Hickam Airways. USAF weather stations, colocated with the aeronautical stations, are designated weather reconnaissance monitors who are charged with acquiring, checking and transmitting reconnaissance reports into the AWN. As does JTWC, these monitor stations receive the data via HF/SSB and phone patch and often copy reports simultaneously with JTWC for efficiency and accuracy.

Reconnaissance aircraft provide vortex data in two stages. The preliminary data, requiring minimum onboard computations, contain enough information to permit JTWC forecasters to begin preparation of warnings. The average delay between the time the preliminary fix data messages were obtained and the time they were copied at JTWC was 19 minutes in 1977 as compared to 15 minutes in 1976, and 21 minutes in 1975. Similar delay times for the second stage, or complete eye/center fix data were 53 minutes in 1977, 30 minutes in 1976 and 49 minutes in 1975. The large difference between the 1976 and 1977 averages is in part due to cases when extremely poor propagation conditions caused exceptionally long delays. Further statistics relating to the efficiency of air/ground aircraft reconnaissance communications are given in Table 2-4.

TABLE 2-4. 1973-1977 AIR/GROUND DELAY STATISTICS FOR AIRCRAFT RECONNAISSANCE

	1973	1974	1975	1976	1977
%Complete fix messages delayed over one hour	20	19	20	21	24
%Complete fix messages received after warning time	10.1	4.9	3.7	4.7	4.9